

INVENTORY OF EQUIPMENT IN THE INSPECTION WORKSTATION

NBSIR 88-3775

May 5, 1988

By:
Jay H. Zimmerman



RAM
RF

**INVENTORY OF EQUIPMENT
IN THE INSPECTION WORKSTATION**

Jay H. Zimmerman

May 25, 1988

This publication was prepared by United States Government employees as part of their official duties and is, therefore, a work of the U. S. Government and not subject to copyright.

Certain commercial equipment, instruments, or materials are identified in this paper in order to adequately specify the experimental procedure. Such identification does not imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

TABLE OF CONTENTS

	<u>Page</u>
I. <u>INTRODUCTION</u>	1
1. WHAT THIS MANUAL IS ABOUT	1
2. AUDIENCE	1
3. OVERVIEW	1
II. <u>COMPUTER SYSTEMS OF THE INSPECTION WORKSTATION</u>	3
1. WORKSTATION CONTROLLER COMPUTER SYSTEM	3
2. COORDINATE MEASURING MACHINE CONTROLLER COMPUTER SYSTEM	4
3. INSPECTION ROBOT CONTROLLER COMPUTER SYSTEM	4
4. SURFACE ROUGHNESS INSTRUMENT CONTROLLER COMPUTER SYSTEM	5
III. <u>INSPECTION WORKSTATION EQUIPMENT</u>	7
1. COORDINATE MEASURING MACHINE	7
2. AUTOMATIC DIAL INDICATOR	7
3. INSPECTION ROBOT	8
4. ROBOT GRIPPER	8
5. SAFETY FENCE	8
6. SURFACE ROUGHNESS INSTRUMENT	8
<u>APPENDICES</u>	11
A. IWS DOCUMENTATION LIST	11
B. IWS EQUIPMENT MANUFACTURERS LIST	13
C. GLOSSARY (and abbreviations)	15
READER COMMENT FORM	17

INVENTORY OF EQUIPMENT
IN THE INSPECTION WORKSTATION

I. INTRODUCTION

1. WHAT THIS MANUAL IS ABOUT

This manual serves as a comprehensive inventory guide to electronic and mechanical equipment and instruments used by the Inspection Workstation (IWS). It furnishes some technical specifications that may be useful in reaching decisions regarding product and system requirements.

2. AUDIENCE

This manual is intended for use by inspection personnel, quality control engineers, advanced metrologists, and plant managers.

3. OVERVIEW

The IWS is a prototype inspection facility with four computer systems and six essential components. The computer systems of the IWS include:

- (a) Main Workstation Controller (WSC),
- (b) Inspection Robot Controller (IRC),
- (c) Coordinate Measuring Machine Controller (CMMC), and
- (d) Surface Roughness Instrument Controller (SRIC).

Principal commercial mechanical and electronic equipment and instruments of the IWS include:

- (a) Horizontal Arm Coordinate Measuring Machine,
- (b) Automatic Dial Indicator,
- (c) Inspection Robot,
- (d) Mechanical (NBS-designed) Robot Gripper,
- (e) Electronic Safety Fence, and
- (f) Optical Surface Roughness Instrument.

Chapters II and III describe the four computer systems and the six components, respectively.

The appendices consist of useful information. Appendix A lists the entire IWS documentation set. Equipment manufacturers specific to the IWS are listed in Appendix B. Appendix C contains a glossary of terms used in this document.

Completing the document is a reader/comment form. The reader is encouraged to write down comments and mail the attached form to the address specified.

IWS EQUIPMENT INVENTORY

II. COMPUTER SYSTEMS OF THE INSPECTION WORKSTATION

The IWS has four computer systems all of which are physically located at the AMRF Inspection Workstation (at NBS), Building 304, Room 148. These computer systems are functionally interdependent based on the AMRF hierarchical control architecture. Notably, each system performs its own unique set of tasks (i.e., main computer system controller, commercial equipment controller, instrument controller, etc.).

All four computer systems are manufactured by Hewlett-Packard (HP) and use the Motorola 16.0 MHz 68000 microprocessor. These computers feature a minimum Random Access Memory (RAM) capacity of approximately 750 kilobytes which is considered necessary and adequate for most current software applications at the IWS.

1. WORKSTATION CONTROLLER COMPUTER SYSTEM

The workstation controller (WSC) computer system uses equipment manufactured by Hewlett-Packard (HP). The components of this system include:

- (a) HP 9000 Series 200 Microcomputer (Model No. 9920U),
- (b) 12-inch Monochromatic Monitor (Model No. 82913A),
- (c) HP-HIL Nimitz Keyboard (Model No. 98203B),
- (d) 16.7-Megabyte (Mbyte) CS/80 Winchester Disc (Model No. 7908P),
- (e) 286.72-Kilobyte (Kbyte) AMIGO Dual 3-1/2 Inch Flexible Disc (Model No. 9121D),
- (f) Three 256-Kbyte RAM Cards (Product No. 98256A),
- (g) Keyboard/HP-IB Interface Card (Product No. 9920A),
- (h) Composite Video Interface Card (Product No. 98204A),
- (i) HP-IB Interface Card (Product No. 98624A),
- (j) RS-232 Serial Interface Card (Product No. 98626A),
- (k) General Purpose I/O (GPIO) Interface Card (Product No. 98622A),
- (l) Data Communication Interface (adds DCE (female, direct-connect) RS-232 cable) (Product No. 98628A Option 002), and
- (m) Pascal 3.0 Language System (Product No. 98615A Option 630).

The computer system contains a Random Access Memory capacity of approximately 786 kilobytes. It functions as the main workstation controller.

2. COORDINATE MEASURING MACHINE CONTROLLER COMPUTER SYSTEM

The coordinate measuring machine controller (CMMC) computer system uses HP-manufactured equipment. The components of this system include:

- (a) HP 9000 Series 200 Microcomputer (Model No. 9836),
- (b) 65.6-Mbyte CS/80 Winchester Disc (Model No. 7912P),
- (c) Line Printer (Model No. 2631B),
- (d) 1.0-MByte RAM Card (Product No. 98257A),
- (e) Three 256-Kbyte RAM Cards (Product No. 98256A),
- (f) General Purpose I/O (GPIO) Interface Card (Product No. 98622A),
- (g) Data Communication Interface (adds DCE (female, direct-connect) RS-232 cable) (Product No. 98628 Option 002), and
- (h) Pascal 3.0 Language System (Product No. 98615A Option 630).

The computer system contains a Random Access Memory capacity of approximately 1,901 kilobytes. It functions as the coordinate measuring machine controller.

3. INSPECTION ROBOT CONTROLLER COMPUTER SYSTEM

The robot controller (IRC) computer system uses HP-manufactured equipment. The components of this system include:

- (a) HP 9000 Series 200 Microcomputer (Model No. 9920U),
- (b) 12-inch Monochromatic Monitor (Model No. 82913A),
- (c) HP-HIL Nimitz Keyboard (Model No. 98203B),
- (d) 28.7-Mbyte CS/80 Winchester Disc (Model No. 7911P),
- (e) 286.72-Kbyte AMIGO Dual 3-1/2 Inch Flexible Disc (Model No. 9121D),
- (f) Four 256-Kbyte RAM Cards (Product No. 98256A),
- (g) Keyboard/HP-IB Interface Card (Product No. 9920A),
- (h) Composite Video Interface Card (Product No. 98204A),
- (i) HP-IB Interface Card (Product No. 98624A),
- (j) RS-232 Serial Interface Card (Product No. 98626A),
- (k) General Purpose I/O (GPIO) Interface Card (Product No. 98622A),
- (l) Data Communication Interface (adds DCE (female, direct-connect) RS-232 cable) (Product No. 98628A Option 002), and
- (m) Pascal 3.0 Language System (Product No. 98615A Option 630).

The computer system contains a Random Access Memory capacity of

approximately 1,048 kilobytes. It functions as the robot controller.

4. SURFACE ROUGHNESS INSTRUMENT CONTROLLER COMPUTER SYSTEM

The surface roughness instrument controller (SRIC) computer system uses HP-manufactured equipment. The components of this system include:

- (a) HP 9000 Series 200 Microcomputer (Model No. 9920U),
- (b) 12-inch Monochromatic Monitor (Model No. 82913A),
- (c) HP-HIL Nimitz Keyboard (Model No. 98203B),
- (d) 16.7-Mbyte CS/80 Winchester Disc (Model No. 7908P),
- (e) 286.72-Kbyte AMIGO Dual 3-1/2 Inch Flexible Disc (Model No. 9121D),
- (f) 1.0-Mbyte RAM Card (Product No. 98257A),
- (g) Four 256-Kbyte RAM Cards (Product No. 98256A),
- (h) Keyboard/HP-IB Interface Card (Product No. 9920A),
- (i) Composite Video Interface Card (Product No. 98204A),
- (j) HP-IB Interface Card (Product No. 98624A),
- (k) RS-232 Serial Interface Card (Product No. 98626A),
- (l) General Purpose I/O (GPIO) Interface Card (Product No. 98622A),
- (m) Data Communication Interface (adds DCE (female, direct-connect) RS-232 cable) (Product No. 98628A Option 002), and
- (n) Pascal 3.0 Language System (Product No. 98615A Option 630).

The computer system contains a Random Access Memory capacity of approximately 2,228 kilobytes. It functions as the surface roughness instrument controller.

IWS EQUIPMENT INVENTORY

III. INSPECTION WORKSTATION EQUIPMENT

1. COORDINATE MEASURING MACHINE

The coordinate measuring machine (CMM) is a Sheffield 2000 Series horizontal arm type (Model No. 2015) coordinate measuring machine manufactured by the Sheffield Measurement Division of Warner and Swasey Company of Dayton, Ohio formerly known as the Automated and Measurement Division of the Bendix Corporation. This measuring machine has direct computer control (DCC) capability and thus meets IWS application requirements for operating in either automatic (computer-assisted) or manual mode. The CMM is equipped with an air-lifted rotary table and a motorized two-axis, three dimensional Renishaw PH9 probe.

The rotary table furnished with the CMM features continuous rotational positioning operated by precision worm with low pitch angle resulting in high-resolution positioning of 0.001 degree. This rotary table is electronically and mechanically interfaced with the CMM for compliance with IWS CAD/CAM application requirements.

The special option probe features adjustable force sensitivity and transmits a latch signal to the processor upon touching an object or part. Normal IWS operation requires the force sensitivity to be set to five grams. This enables most parts to be automatically inspected by the CMM unmounted, or unsecured, to the measuring machine. Small parts, however, must be secured by some sort of fixture (i.e., magnetic device, or vacuum chuck, etc.).

The PH9 probe has a built-in microprocessor that is programmable for up to sixty-four probe tip positions, or orientations. The probe is powered by the interface to the CMM. When power to the interface is disconnected, the probe orientations may be retained in the memory of the PH9 microprocessor for several hours using the microprocessor's internal battery.

2. AUTOMATIC DIAL INDICATOR

The automatic dial indicator (ADI) is a digital dial gauge (Model No. 8X-0047) manufactured by Brown and Sharpe Manufacturing Company of North Kingstown, Rhode Island. This instrument is used for sensing and measuring distance variations. The mechanism of the indicator converts the axial displacement of the measuring spindle into rotational movement which is then amplified by mechanical means and finally displayed by digital readout. This indicator has a RS-232 output for providing direct communication of measurement readings to the SRI controller computer system.

3. INSPECTION ROBOT

The inspection robot is a six-axis robot (Model Merlin) manufactured by American Robot Corporation of Pittsburgh, Pennsylvania. This robot is mounted on an overhead gantry for easy access to the work environment of the IWS workstation. It is equipped with a CNC controller and a robot gripper discussed in the next section.

4. ROBOT GRIPPER

The robot gripper is an NBS-designed and manufactured mechanical-transporting device operated with the Merlin robot of the IWS. It has one set of fingers and is pneumatically actuated, exerting forces up to fifty pounds. For most IWS applications, the gripper fingers are adjusted to exert a force of fifty pounds to handle the tasks of transporting and relocating inspection parts.

5. SAFETY FENCE

The safety fence employed at the IWS is an electronic sensing device (Model No. SS IV-18-R) manufactured by Dolan-Jenner Industries, Incorporated of Woodburn, Massachusetts. This safety fence monitors personnel infiltration into restricted areas of the IWS, particularly during intervals of on-going inspection operations. It has data communications output for providing direct communication with the robot computer system.

6. SURFACE ROUGHNESS INSTRUMENT

The surface roughness instrument (SRI) is an optical instrument (Model No. RM 400) manufactured by Rodenstock Precision Optics, Incorporated of Rockford, Illinois. This instrument examines surface roughness by measuring the angular distribution of scattered light. It employs a beam from a helium-neon laser illuminating the surface at an angle of incidence which may be varied. The scattered light distribution is detected by an array of twenty optical detectors.

This portable, hand-held, commercial device satisfies the requirements of the IWS for non-contact, real-time surface finish inspection. The current instrument system contains the control unit (Rodenstock (Model No. RM 400 C)) and a sensor device (Rodenstock (Model No. RM 400 S)) with a type 40, straight-design measuring head having a measuring spot diameter of 1.8 millimeters and 20-degree optics. The sensor device contains a detector array to collect the angular distribution, which is then processed by the control unit software. The control unit has a RS-232 output for providing direct communication of measurement readings to the SRIC computer system. The SRIC evaluates measurement data

and sends information to the inspection robot controller (IRC) computer. This information represents essential data concerning the proper alignment of the surface of a part with respect to the sensor device.

As a special note, the product manufacturer of this instrument provides additional sensor types for special applications. At the present time, NBS personnel have found the standard (type 40) sensor with a spot diameter of 1.8 millimeters and 20-degree optics the most versatile for inspecting surface finishes of parts manufactured in the AMRF facility.

IWS EQUIPMENT INVENTORY

APPENDICES

A. IWS DOCUMENTATION LIST

1. H. T. Moncarz, Architecture and Principles of the Inspection Workstation, to be published as an NBSIR.
2. H. T. Moncarz, Implementation of the Execution Control System of the Inspection Workstation, NBSIR 88-3787, May 19, 1988.
3. H. T. Moncarz and T. H. Hopp, Implementation of the CMM Controller, to be published as an NBSIR.
4. H. T. Moncarz and T. V. Vorburger, Implementation of the SRI Controller, to be published as an NBSIR.
5. H. T. Moncarz and B. Borchardt, Implementation of the Inspection Robot Controller, NBSIR 88-3772, April 21, 1988.
6. S. A. Osella, Implementation of the Workstation Controller, to be published as an NBSIR.
7. J. Zimmerman, Inventory of Equipment in the Inspection Workstation, NBSIR 88-3375, May 5, 1988.
8. H. T. Moncarz, S. A. Osella, B. Borchardt, and R. Veale, Operations Manual for the Inspection Workstation, NBSIR 88-3766, April 21, 1988.
9. J. Zimmerman, Recommended Technical Specifications for Procurement of Commercially Available Systems for the Inspection Workstation, NBSIR 88-3779, May 11, 1988.

IWS EQUIPMENT INVENTORY

B. IWS EQUIPMENT MANUFACTURERS LIST

1. Coordinate Measuring Machine
Sheffield Measurement Division
Warner and Swasey Company
721 Springfield Street
Dayton, Ohio 45403
(513) 254-5377
2. Automatic Dial Indicator
Brown and Sharpe Manufacturing Company
Precision Park
North Kingstown, Rhode Island 02852
(401) 866-2000
3. Inspection Robot
American Robot Corporation
121 Industry Drive
Pittsburgh, Pennsylvania 15275
(412) 787-3000
4. Robot Gripper
United States Department of Commerce
National Bureau of Standards
Building 220 Metrology Room A107
Gaithersburg, Maryland 20899
Attn: Bruce Borchardt
(301) 975-3482
5. Safety Fence
Dolan-Jenner Industries, Incorporated
Post Office Box 1020-T
Woodburn, Massachusetts
(617) 935-7444
6. Surface Roughness Instrument
Rodenstock Precision Optics, Incorporated
4845 Colt Road
Rockford, Illinois 61109
(815) 874-8300
Telex 28-9425

IWS EQUIPMENT INVENTORY

C. GLOSSARY (and abbreviations)

ADI Abbreviation for the Automatic Dial Indicator.

automatic dial indicator

Instrument used to measure the distance that a spring mounted stem is depressed.

CMM Abbreviation for the Coordinate Measuring Machine.

CMMC Abbreviation for the Coordinate Measuring Machine Controller.

controller

Supervises the operation of a mechanism and/or another controller.

coordinate measuring machine

Machine used to measure the dimensions of a part.

inspection robot

Robot used in the Inspection Workstation to retrieve and/or relocate a part.

inspection workstation

AMRF workstation that inspects parts for dimensional tolerance and surface finish.

IRC Abbreviation for the Inspection Robot Controller.

IWS Abbreviation for the Inspection Workstation.

Kbyte Abbreviation for kilobyte (1024 bytes).

Mbyte Abbreviation for megabyte (1,048,576 bytes).

RAM Abbreviation for Random Access Memory.

SRI Abbreviation for the Surface Roughness Instrument.

SRIC Abbreviation for the SRI Controller.

surface roughness instrument

Machine that measures the optical scattering from the surface of a part. The scattering can be correlated with its surface roughness.

WSC Abbreviation for the Workstation Controller.

IWS EQUIPMENT INVENTORY

READER COMMENT FORM

INVENTORY OF EQUIPMENT IN THE INSPECTION WORKSTATION

This document is one in a series of publications which document research done at the National Bureau of Standards' Automated Manufacturing Research Facility from 1981 through March, 1987.

You may use this form to comment on the technical content or organization of this document or to contribute suggested editorial changes.

Comments: _____

If you wish a reply, give your name, company, and complete mailing address: _____

What is your occupation? _____

NOTE: This form may not be used to order additional copies of this document or other documents in the series. Copies of AMRF documents are available from NTIS.

Please mail your comments to: AMRF Program Manager
National Bureau of Standards
Building 220, Room B-111
Gaithersburg, MD 20899

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET (See instructions)	1. PUBLICATION OR REPORT NO. NBSIR 88-3775	2. Performing Organ. Report No.	3. Publication Date MAY 1988
4. TITLE AND SUBTITLE "INVENTORY OF EQUIPMENT IN THE INSPECTION WORKSTATION"			
5. AUTHOR(S) Jay H. Zimmerman, Precision Engineering Division, Dimensional Metrology Group			
6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions) NATIONAL BUREAU OF STANDARDS DEPARTMENT OF COMMERCE WASHINGTON, D.C. 20234		7. Contract/Grant No.	8. Type of Report & Period Covered
9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP) National Bureau of Standards Route 270 and Quince Orchard Road Gaithersburg, Maryland 20899			
10. SUPPLEMENTARY NOTES <input type="checkbox"/> Document describes a computer program; SF-185, FIPS Software Summary, is attached.			
11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here) This document is a comprehensive inventory guide to electronic and mechanical equipment and instruments used by the Inspection Workstation (IWS) in the Automated Manufacturing Research Facility (AMRF) at the National Bureau of Standards. The IWS is a prototype inspection facility with four computer systems and six essential components. The computer systems of the IWS include the Main Workstation Controller (WSC), the Inspection Robot Controller (IRC), the Coordinate Measuring Machine Controller (CCMC), and the Surface Roughness Instrument Controller (SRIC). The principal commercial mechanical and electronic equipment and instruments include the horizontal arm coordinate measuring machine (CMM), the automatic dial indicator (ADI), the inspection robot, the mechanical (NBS-designed) robot gripper, the electronic safety fence, and the optical surface roughness instrument (SRI).			
12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons) Automatic dial indicator; controller; coordinate measuring machine; Inspection Workstation; inventory; robot; surface roughness instrument			
13. AVAILABILITY <input checked="" type="checkbox"/> Unlimited <input type="checkbox"/> For Official Distribution. Do Not Release to NTIS <input type="checkbox"/> Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. <input checked="" type="checkbox"/> Order From National Technical Information Service (NTIS), Springfield, VA. 22161		14. NO. OF PRINTED PAGES 22 15. Price \$9.95	